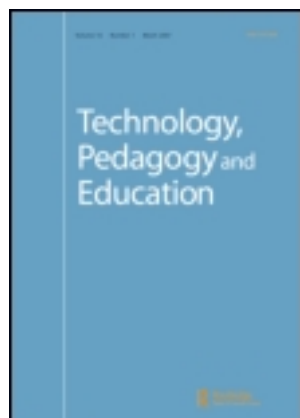


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Levels of use of Interactive Whiteboard technology in the primary mathematics classroom

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Despite the availability of Interactive Whiteboard (IWB) technology in a large number of Australian primary schools, many teachers focus only on technical issues as opposed to pedagogical engagement in an attempt to incorporate the technology. Previous research suggests that the technology is being used for sophisticated transmission-style teaching as opposed to constructivist approaches. This article presents findings of a project that considered the implementation of IWB technology in three Victorian primary mathematics classrooms (5 to 12 years of age). The study analysed the teaching strategies adopted by three teachers as they embarked on the use of IWB technology as an integral component of mathematical activities with the support of professional development. Teacher use of IWB technology in the primary mathematics classroom was aligned against Beauchamp's generic transitional framework for viewing the development of teacher use of IWB technology. Through this alignment, a transitional framework emerged which is specific to the introduction of IWB technology in the mathematics classroom.

Keywords: Interactive Whiteboard technology; primary education; mathematics; teacher professional development

It is widely recognised that an understanding of the potential of Information and Communication Technology (ICT) in the classroom requires a study of the pedagogy at the basis of the use of equipment. Despite the growing availability of a wide range of technological tools, there has been little adoption of new technology to develop concepts in the primary classroom, particularly in the context of mathematics. There is an identified need for professional development that focuses on the adaption of teachers' 'pedagogical reasoning and practices in response to learning opportunities provided by ICT' and it 'is likely to be a very difficult and complex process' (Webb & Cox, 2004, p. 278).

Many classroom teachers confidently use technology as a presentation or display tool, but remain unaware of the potential for ICT to promote concept development in the mathematics classroom. This use of technology was emphasised by Fitzallen

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(2005, p. 353) through the recognition of 'a need for teachers to gain an understanding of how Information and Communication Technology can be used to extend students' thinking and problem-solving skills, rather than just a publication and research tool'. The work of Webb and Cox (2004, p. 235) provides evidence that suggests that 'new affordances provided by ICT-based learning environments require teachers to undertake more complex pedagogical reasoning than before in their planning and teaching that incorporates knowledge of specific affordances and how these relate to their subject-based teaching objectives as well as the knowledge they have always needed to plan for their students' learning'. Tanner, Jones, Beauchamp, and Kennewell (2010) likened this to the contrast between classical orchestration and jazz improvisation. They suggested that teachers needed to create spaces in their teaching time for improvisation and interactions among students, teachers and the technology to occur.

The Interactive Whiteboard (IWB) and associated technology, such as supporting software, websites, and school pads, is an educational resource that requires specific attention in relation to the affordances provided and student-centred pedagogies related to their application. Affordances may include being a catalyst for classroom discussion, movement from informal to formal language use, and the development of mathematical ideas. The IWB is a touch-sensitive display board, sensitive to finger- or pen-like devices, used in conjunction with a computer and a digital projector. The IWB technology used as a medium in this project was a school pad. The school pad is a portable A4-size template which is touch sensitive, to allow students to manipulate the IWB technology from any position in the classroom. Although the number of classrooms in Australia that have IWB technology installed is unknown, there are a large number of schools at all levels that have purchased and/or installed the technology and intend using IWBs during mathematics lessons. It is evident that both teachers and students are enthusiastic about using IWB technology in the classroom, but it is not clear if this excitement and enthusiasm is transformed into effective teaching strategies and meaningful mathematical experiences (Tanner & Jones, 2007).

Deaney, Ruthven, and Hennessy (2001, p. 142) stated that the supply of technology is of limited value without an understanding of 'the interactions and processes engendered by using technology in different settings, and how pedagogical strategies to enhance students' learning might be developed effectively through them'. This suggestion echoed McGehen and Griffith's (2004) contention that teachers must develop an appreciation of the ways in which technology can enhance and encourage mathematical thinking. It has been claimed, however, that IWB technology can reinforce teacher-centred pedagogy, leading to students becoming passive recipients of information rather than active, engaged learners (Moss et al., 2007).

Hall and Higgins (2005) investigated the embedding of ICT within teaching strategies to enhance literacy and numeracy skills. When carrying out rigorous reviews that compared student activity in classrooms with IWB technology with activity in classrooms without, they found no changes in teaching and learning practices. The IWB classroom situation as described by Kennewell (2007, p. 4) involves teaching strategies that rely on whole-class teaching with less group-orientated tasks. Whilst open-ended questions are presented through the technology, the students appear to provide fewer responses to the stimulus and the material is presented at a faster pace. Open items have the affordance of creating 'a response using whatever resources he/she can bring to bear, hence producing a constructed

response' (Collis & Romberg, 1991, p. 102). Kennewell suggests that such affordances are not realised due to the fast pace of material presented and surface learning is the result of the activity.

A number of themes have been identified in relation to students' perceptions of problems when using IWB technology. These perceptions included technical problems with the equipment, varied levels of ICT skills of teachers and students, and lack of student access to the IWB technology during the classroom activity. Researchers have found that 'while the technology is clearly engaging from the students' perspective there is a concern that any gains in this direction will be lost if the technology is not reliable, if teachers are not adequately trained to use it, and perhaps more importantly, if the educational climate militates against increased pupil access to the technology' (Hall & Higgins, 2005, p. 114). This finding suggested that both teachers and students needed experience in 'playing' with new technology, and teachers should have professional development that addresses both skill-based aspects of technology use and effective pedagogical approaches when technology is used. In relation to this latter issue, Smith, Hardman, and Higgins (2006, p. 456) stated that 'more extensive research needs to be carried out into ways of effectively supporting teachers in their professional development in order to promote more reciprocal forms of teaching to increase the opportunities for extended teacher-pupil interaction'.

Pupils' perceptions of IWBs have been described as ranging from excitement to frustration. Children relay that they 'value the use of the IWB for whole-class games; exploring the internet together; its visual, aural and tactile properties; and multimedia presentations' (Kennewell, 2007, p. 4). In addition to these, Hall and Higgins (2005) identified student perceptions that included frustration with technical difficulties, a lack of technical skill in terms of teacher and students, a lack of equity in relation to involvement and contact with the board, and physical difficulties in terms of visibility of the IWB from their desk.

Recent research into the application of IWBs has centred on teacher roles. Kennewell (2007, p. 7) describes the following teacher roles as typical when using IWB technology:

Consultant – providing information, such as prepared 'answers' for discussion; planned or ad hoc internet searching; exploring simulations.

Organiser – providing tight structure but unpredictable results for activities, such as games, so that the teacher is free to discuss strategies with the students as equal participants.

Facilitator – providing a looser structure for focussing on construction activities involving choice, such as annotating or matching tasks, where teacher/students can discuss options and guide the less knowledgeable.

Repository – enabling student ideas to be recorded for later revising, reflection, and revision.

From another perspective, the work of John and Baggott La Velle (2004) has centred on levels of application of ICT in the classroom. The researchers identified three levels of interaction with the technology known as assimilation, accommodation, and 'retreatism' and there was teacher movement between these levels. Assimilation involved an active incorporation of ICT into their practice. There were levels

of penetration evident which were dependent upon the ‘competence and confidence of each individual’ (p. 323). The teachers who made various accommodations with ICT tended to integrate their existing teaching strategies and modes of practice in a pragmatic manner. This is reiterated by Rogers and Finalyson (2004, p. 302) who identified that for ‘the majority of teachers, success with ICT was founded on adapting the use of ICT tools to match their existing pedagogy’. Unlike Kennewell (2007), John and Baggott La Velle (2004) identified an additional level of classroom technology use that involves retreating from the technology:

Those who exhibited retreatism were more recalcitrant users and often reacted strongly against ‘techno-fundamentalism’. They also believed that ‘technical’ incursions into their subject areas represented a significant threat, believing it to be a classroom competitor which might derogate their subject and pedagogic identity. (p. 323)

Beauchamp (2004) suggested a generic transition framework to describe the developmental stages in IWB use from the novice to the expert. The stages consider operating system use and file management, mechanical skills, program variables, and classroom management and pedagogy. The five-level framework is summarised as:

- (1) Black/Whiteboard Substitute: the teacher continues to function in a similar teaching style. There is ‘no fundamental change in their pedagogy which is needed to incorporate the integration of new technologies’ (p. 331).
- (2) Apprentice User: This stage of development is ‘characterised by use of a wider range of existing computer skills in a teaching context, although lessons still proceed in a largely linear direction’ (p. 334). Students use the board within the lesson and familiar programs such as PowerPoint are used as a medium for information with minimal use of external material from the internet.
- (3) Initiate User: The key change at this stage is ‘awareness of the potential of the IWB to change and enhance practice’ (p. 338). A new pedagogy emerges that combines the skills of the teacher and the students where a range of resources are explored. Increased student involvement is present, however it is planned by the teacher and is a physical action. The student involved is limited to the manipulation of IWB tools which do not lead to conceptual development.
- (4) Advanced User: The teacher is now in a phase of exploration where new features such as hyperlinks, sound files, and graphics are added to existing lesson structures. Students are engaged as active participants and this may involve student access to IWB class pads.
- (5) Synergistic User: The foundation of the final stage is ‘the growing equality of teacher and pupil’. There is a focus on opportunities to create ‘new learning scenarios’ where the teacher demonstrates ‘an intuitive interaction with technology which facilitates a fluid lesson structure’ (p. 343).

The study reported in this article involved three teachers who were implementing IWB technology in their primary classrooms for the first time. Predominantly, Australian primary students (aged 5 to 12 years) are taught by a single generalist teacher (without a specialisation in any key learning area) for the majority of the

school day. Exceptions to this often include music and physical education. The generalist primary teachers in the study reported here were supported through professional development sessions in which they were introduced to developmental models of learning with a teaching framework provided by the pedagogical phases developed by Dina van Hiele-Geldof (van Hiele, 1986). The five teaching phases aim to facilitate the cognitive development of a student through the transition between one level of development and the next. The phases originate from the idea that ‘help from other people is necessary for so many learning processes’ (van Hiele, 1986, p. 181). Learning is deemed a social process and stems from the notion that students find it very difficult to move unassisted from one thought level to the next. This idea, however, is exactly what IWB technology appears to inhibit (Tanner & Jones, 2007). The use of van Hiele’s teaching phases addressed the concern that ‘teachers often feel reluctant or uncomfortable because their pedagogical knowledge perhaps does not include a framework for conducting technology-based activities in their lessons’ (Chua & Wu, 2005, p. 387).

The first professional development meeting introduced the teachers to the school pad and its associated software. Teachers were able to use the school pads and to explore the range of possibilities offered. The later professional learning sessions were explicit about linking technology use to concept and cognitive development. Teachers saw use of the IWB technology modelled in presentations, were able to experience using the school pads and to interact with computer programs in ways that promoted developmental ideas.

With this background, the research questions for this study were:

- (1) What are the stages of development in teacher use of the interactive white-board technology in the primary mathematics classroom?
- (2) What issues arise concerning professional development when introducing technology into primary mathematics classrooms?

Method

The study took place over one school year in 2007. One school year in Victoria, Australia, comprises four 10-week terms, beginning in January and ending in December. Teachers were supplied with a school pad and undertook to use it in mathematics lessons wherever possible. The particular focus was the space strand of mathematics, because this had been identified as an area of need by the schools involved. Apart from these commitments, no restrictions were placed on teachers as to how they implemented IWB technology within their different contexts.

Sample

The teachers involved came from three different primary schools in Victoria, Australia. School A was situated in a suburban area. It had an enrolment of approximately 450 students, of whom more than 80% spoke English as a second language. The teacher, Mark, taught a year 6 class. He was an experienced teacher having taught for about 10 years. The classroom was equipped with an interactive

whiteboard, as well as a small school pad supplied through the project. School B was also suburban. It had 600 students, mainly of Anglo-Celtic origins. The teacher, David, taught a year 5 class. He was the least experienced classroom teacher, having come into teaching as a mature-age entrant after a varied career, including some time teaching in the TAFE (vocational) sector. The school pad supplied by the project was the only access to IWB technology, but he also made use of a computer laboratory. School C was situated in a country town. This school was a small school of approximately 133 students. The teacher, Agnes, was very experienced having taught for well over 20 years, and she also held a Master's degree. She taught a year 4 class, and the school pad provided the only access to IWB technology in the school.

Data collection and analysis

Data were collected on different occasions including three professional learning sessions, both held in participating schools, and a site visit to each school at which the teachers' classes were observed using the school pads in mathematics lessons. Particular attention was paid to the ways in which the students used the school pad, and the teachers' questioning. At the professional learning sessions, teachers received training in the use of the school pads and input about developmental approaches to teaching the space strand, with particular reference to the use of IWBs, and reported their classroom experiences and activities. The final data source was student work samples provided by the teachers or collected during school visits. Observations were collected using field notes focussing on the kinds of activity being undertaken by the children, photographs of classroom activity and work samples produced using IWB technology.

These materials were examined by each researcher independently, and then discussed at length to categorise the nature of the IWB use. Records of the meetings and classroom observation data were analysed qualitatively using a clustering approach (Miles & Huberman, 1994) to identify levels of use of IWB technology in the primary mathematics classroom through the application of Beauchamp's (2004) generic transition framework. The focus was on the quality of children's interactions with each other and the teacher through the school pad tool, and the nature of the mathematical thinking addressed. The van Hiele levels (van Hiele, 1986) provided a framework for the analysis of children's work, and special consideration was given to evidence of teachers' expectations of higher order thinking. This process was iterative, in that after each discussion the materials were reconsidered and further conversations were held until the researchers were satisfied with their categorisation. At this point, a seminar was held within the Faculty of Education and the results presented to peers for further comment. Minor adjustments were made to the classification following this session.

The categories that emerged were formed on the basis of the similarities and differences observed in the data when aligned with the descriptions of each level in the Beauchamp (2004) framework. The work samples were used to triangulate teachers' comments about their students' progress, through comparison with the teacher-described outcomes of the learning tasks to assist in the identification of each teacher's transitional level of IWB technology in the classroom. The results present a description of the four identified clusters of teacher use, followed by a

discussion that considers the identified clusters in relation to the two research questions.

Results

The results are presented as four categories of teacher use of IWB technology, followed by a synthesis of the manner in which the identified categories of IWB teacher use align with the Beauchamp (2004) framework.

Category one: Black/Whiteboard Substitution

Two of the three teachers, namely Mark in School A and David in School B, predominantly displayed the first transition phase of Beauchamp's (2004) framework, that is, Black/Whiteboard Substitution. In School A, Mark made less use of the school pad than the large wall-mounted IWB. He used some features of the IWB software effectively to develop students' understanding. In particular he used the spotlight or curtain feature to reveal gradually a two-dimensional shape, providing a virtual equivalent of a well-known activity included in the Early Years Numeracy Research Project assessment interview (Clarke et al., 2002). This was a common strategy used by the teacher prior to the availability of the IWB technology. The IWB was used to replace the cardboard previously used to reveal the unknown shape.

Student work samples resulting from these strategies were revealing. All teachers expressed the view that their students had been more engaged and motivated by the use of the school pads, and that their learning had benefited. Certainly the students observed were confident and engaged by the technology. Despite the students' fluency in using the technology, however, the focus of this use tended to be on presentation rather than the mathematical ideas.

Category two: Apprentice User

By the third term, students in School A produced a PowerPoint report about angles and the strategies used aligned closely with Beauchamp's (2004) level of teacher use named Apprentice User. In addition to PowerPoint, Mark was also making use of support materials provided electronically by the education system through the internet, as well as other public internet sites, including TeacherTube (<http://www.teachertube.com/>). These motivated and interested the students in mathematical topics, however there was a lack of critical engagement with the online material presented. There was a limited use of external material and its use remained in the form of a presentation tool.

By third term, David in School B had planned and implemented a fully online unit of work around properties of shapes. Students were making extensive use of technology in a number of ways, including exploring shape, creating a PowerPoint and submitting this for assessment electronically through the school intranet. Students were able to act autonomously in their choice of shapes to explore, and it was noticeable that many had chosen relatively unusual shapes, such as nonagons. Use of the school pad appeared to be restricted to individuals taking it in turns to practise using the tool, although David did say that he was using this in other ways in subjects outside mathematics.

Category three: Initiate User

Only one teacher, Agnes of School C, demonstrated use of the IWB technology consistent with the level of Initiate User. The focus in this classroom was on group work with several activities all addressing the same general topic of 3D objects and their properties. Agnes had laid down some rules for use of the school pad. Each student had to take a turn so that collaboratively the group created a representation of a 3D object. In the observed lesson, a group was working cooperatively using isomorphic dot 'paper' and the school pad to draw a square-based pyramid. This created much discussion among the students in the group about where to draw the lines and whether the representation was accurate. The rest of the class was undertaking a variety of activities, including building with concrete materials, writing about a chosen shape in their mathematics books and using drawing packages on computers to explore 3D shapes. Agnes stated that she felt that the most powerful aspect of the IWB technology was the conversations it created among the students.

Agnes explicitly linked concrete objects, skeleton models of 3D shapes using play dough and matchsticks, virtual representations using the school pad and isomorphic dot 'paper', and the language of geometry in her questioning and review at the start and end of the lesson. Technology use is not independent of the teacher, although Agnes reported that once the students were familiar with the technology she left them alone using the school pad while she worked with other groups.

Category four: Technical Deficiency or Retreatism

The last category of teacher use is not evident in Beauchamp's (2004) framework but was evident in Schools B and C at the start of the project. This category concerns lack of teacher use of IWB technology due to a predominant focus on technical difficulties, time constraints, and specific perceived lack of suitability of the targeted concepts for IWB use in the classroom (John & Baggott La Velle, 2004). David, in School B, made extensive use of technology during the project, including the school pad, however there was a period of one term where he procrastinated about implementation of the technology in the classroom. David made statements such as 'I needed to get my head around it first.' He also found some difficulty working with the technology until he was able to set up the necessary computer and data projector permanently in his classroom.

The younger students in Agnes' class, School C, were impressively fluent in their use of technology. In this school, as in School B, infrastructure was an issue. Access to data projectors and screens was limited and Agnes had to rely on make-shift arrangements using window blinds to project the image. Issues such as these limited the level of teacher use of IWB technology at the initial stage in each of the schools.

Two common themes emerged at the teacher meetings in relation to the teacher use at this level. The first was the difficulty of getting underway with the technology. Apart from Mark in School A, who had a large IWB fixed in his classroom, the other schools had no experience in IWB use and did not have appropriate hardware easily available. Although all schools possessed data projectors and teachers had laptop computers, accessing the projector was not easy. It often involved planning ahead and booking the projector for a given time. These difficulties, on top of coming to terms with new teaching approaches and a new tool, proved challenging.

Whilst the technical problems were clearly articulated there was a reluctance to solve problems in the initial level of Retreatism.

The second issue was teachers' relative lack of understanding of the content area of geometry. There were often comments such as 'I hadn't realised that' or 'I have never been taught this' when they were undertaking tasks designed to focus on geometrical understanding. Although all the teachers involved were widely experienced they readily acknowledged gaps in their mathematical knowledge.

It was evident that when the teachers were no longer displaying teacher use within the Retreatist category, the focus of comments at the teacher meetings was on the motivational power of IWB technology. The teachers reported that the students repeatedly commented on the 'fun' nature of the equipment and their desire to use it again. There were multiple comments on the manner in which the IWB enhanced the students' interest level during mathematical activities. The students' work samples endorsed this impression with comments such as: 'Using the interactive whiteboard was a bit challenging but was fun when you put your mind to it. It was a very fun activity to do' and 'I enjoyed using the Interactive Whiteboard. At first it was hard but after a while it became easy. It was lots of fun! ☺.'

Discussion

Research question 1

There were four categories of teacher use of IWB technology observed in the three classrooms over the teaching year (four 10-week terms). Three of the categories aligned with three of the five levels of transitional use of IWB technology in the classroom defined by Beauchamp (2004), these being, in order of development, Black/Whiteboard Substitute, Apprentice User, and Initiate User (Categories One, Two and Three). The initial and lower level of teacher use (Category Four) observed in this sample, that did not appear in Beauchamp's (2004) framework but was observed as a significant hurdle to overcome, aligned with an element of John and Baggott La Velle's (2004) role description of Retreatism. This initial level of use was characteristically driven by an additional lack of technical skill. When aligned with Beauchamp's framework this level is recognised as Level 0.

The reason for using school pad technology, as opposed to large fixed IWBs, was to encourage interaction among students beyond 'turn taking'. Despite this, of the three teachers observed, only Agnes in School C was operating as an Initiate User that encouraged the children to select IWB tools. It is interesting to note that although Agnes did not have access to a fixed IWB and initially described this as a limitation characteristic of the Retreatist level of use, the collaborative small group tasks she designed which utilised the school pad were constructivist in nature and allowed the students to formulate and discuss their mathematical ideas. Agnes ended the year as an Initiate User of the technology.

It was evident that the teacher use of IWB technology as a large display in the classroom led to a tendency for Mark in School B to adopt transmission-style teaching approaches, with the focus of the activity concerning the pupils' development of new technological skills rather than mathematical ideas. This transmission style occurred despite Mark's enthusiastic engagement with the pedagogical frameworks. The approach used by Mark is consistent with Beauchamp's (2004) level of Apprentice Use and highlights the technical and pedagogical hurdles to be

overcome before the teacher is able to embed the IWB technology into the teaching/learning sequence as a teaching tool.

In contrast, there appeared to be benefits in pupils having direct access to the school pads during geometry activities in association with the use of concrete materials as observed in Agnes' classroom in School C. Engaging pupils in a combination of small group constructions with concrete materials, electronic geoboard constructions, and written recording of known properties and relationships of shapes seemed effective in focussing students on the mathematics. In addition, Agnes took the time to bring the groups of students together as a class to discuss the activities providing an avenue for the students to share their mathematical findings and develop mathematical language. This strategy is consistent with those reported by Moss et al. (2007) who described the need to focus on students as active and engaged learners. This pedagogical issue emphasises the comments of Deaney et al. (2001) that highlight the importance of student interactions and strategies that promote interaction in the technological environment. Such interactions also appear to be typical of Beauchamp's (2004) Initiate level.

There were positive factors in relation to the motivational aspects of IWBs, but the 'fun' and 'pretty' side of the mathematical activities appeared to impinge negatively on the development of mathematical concepts in the first three levels of use identified in this study, namely Retreatism/Technical Deficiency (Level 0), Black/Whiteboard Substitute (Level 1) and Apprentice User (Level 2). Although the students enjoyed presenting mathematical concepts in a variety of technological forms, the display emphasis lost sight of the potential of the equipment as a teaching tool. In contrast to this, in the Initiate level of use (Level 3) observed in Agnes' classroom, her apparently more effective lessons engaged the students in mathematical investigations and problem-based learning tasks, without an emphasis on producing a display such as slides or booklets. Such a finding is in line with Fitzallen's (2005) thinking.

Typical of the levels of Black/Whiteboard Substitution and Apprentice User, teachers did use aspects of the provided software, however this use appeared to be limited to drawing, or interactive games. David in School A, for example, used the geometric shapes to produce tessellations but this provided a digital mimicry of the use of pattern blocks and did not seem to lead to a deeper understanding of the conditions under which a shape would tessellate. Such use locks students into lower levels of thinking, but this may also have been reinforced by the teachers' own perceived lack of knowledge.

It appeared that IWB technology was motivational and encouraged students' interest across the four observed levels. Unless careful thought was given to the pedagogy, however, student learning in mathematics was not greatly enhanced and the potential gains from their increased interest not realised.

Research question 2

The issues that emerged during this small initial study provide insight into the levels of teacher use of IWB technology in the primary mathematics classroom. Access to appropriate infrastructure was critical and the time teachers took to get underway with the project was increased when this support was not available. The initial level of teacher use, which involved Retreatism and lack of technical skills, can be a difficult and time-consuming hurdle to overcome. This was evident with two of the

three teachers in this study. The technology itself was not effective unless teachers carefully planned and thought through their teaching approaches. The professional development sessions were important to support teachers' growing understanding of appropriate pedagogical approaches, in line with research findings from elsewhere (Hall & Higgins, 2005). It is interesting to note that one of the three teachers moved from the Retreatist/Technical Deficiency level to an Initiate User within the school year and there was an identifiable link between the planning of her lesson sequence using the provided theoretical framework and using IWB tools.

The finding that the large wall-mounted IWB was more consistent with teacher-centred approaches, particularly within the levels of Black/Whiteboard Substitute and Apprentice levels of use, was also indicated in the literature (Moss et al., 2007). The small school pads, used appropriately, as in the Initiate use, did appear to have potential for encouraging student-student and student-teacher interaction, and this may be a fruitful area for further research. Such findings highlight an area of need identified by Webb and Cox (2004, p. 273) where 'current literature is focussing on distance collaboration rather than peer interaction around a computer, which has been neglected recently, and software design needs to take more account of classroom practice among young children such as "turn taking"' (Webb & Cox, 2004, p. 273).

The call for a framework for conducting technology-rich lessons (Chua & Wu, 2005) was also borne out by the findings. Teachers appreciated the value of the van Hiele (1986) teaching phases, but in this short study were able only to develop a surface understanding of the possibilities. Nevertheless, the use of such frameworks to develop lessons using technology appears to have potential.

Conclusion

Through the analysis of the categories of teacher use of IWB technology in the primary mathematics classroom, the findings include four levels of teacher use, Levels 0 to 3, within the observed one-year period as they made the transition. It wasn't until the teacher use reached the level of Initiate User that student-centred mathematical activities using IWB technology as a teaching tool appeared. This level of use required the teacher to facilitate tasks considered to be the most appropriate place to use the IWB within a developmental teaching sequence. The students enjoyed direct access to the equipment regardless of the task, but gained most benefit when actively involved in tasks which challenged their mathematical thinking and allowed for communication with their peers. The technology tasks were embedded in a range of activities that explicitly addressed different phases of the van Hiele teaching sequence. There was a tendency to rely on the display nature of IWBs in the classroom in the Black/Whiteboard Substitute and Apprentice levels of use, leading to lessons where the final result of the activity was the display of pre-existing student ideas. The analysis of teacher use of IWBs in three different contexts emphasised the need to provide sustained professional development that focussed on the place of IWB technology in the light of known developmental frameworks in mathematics education, providing a useful platform for further research. These findings support the recommendations of Miller and Glover (2007, p. 330) who stated that effective professional development of mathematics teachers requires the teacher to 'work with either an internal or external mentor from an early stage, and be allowed time for exploration, consolidation and the development

of teaching materials as confidence and competence develop' with time devoted to 'regular discussion of teaching approaches using IWBs'. An adaption of the van Hiele teaching phases in the form of user-friendly titles and descriptions to promote the use of IWB technology has the potential to provide a useful framework for professional development in the area of primary mathematics education.

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